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**PANDEMICS, ECONOMICS AND RESILIENCE**

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Abstract <p>Pandemics and epidemics have occurred throughout human history, with significant impacts to both population and societies. Their economic impacts, however, have seen only limited research. Research has been limited by the lack of data and empirical evidence, due to the rarity of large-scale pandemics. For this reason, the estimates about the economic impacts of pandemics that have been made have had to use a lot of assumptions and guesses. The subject of economic resilience to pandemics is largely untouched in past research, and parts of this thesis focus on that. It is an interesting concept that deserves further attention.</p> <p>The current COVID-19 pandemic, caused by a coronavirus strain called SARS-CoV-2, has put the previous models and estimates to a test. The scale and speed of its economic impacts have been unprecedented and partly unexpected, with government spending and unemployment rising rapidly in many countries. The purpose of this thesis is to give the reader a background about both past pandemics and past research into the economic impacts of pandemics. Knowledge about past events and literature helps to understand both realised and potential economic impacts of the current pandemic. This thesis can also be used as a starting point for future research.</p> <p>Different policies to stop the spread of the pandemic are reviewed from multiple perspectives, utilising previous and current research. There seems to be an optimal policy when considering economic, social and health impacts. Quick reaction with heavy restrictions on mobility combined with extensive testing seems to minimise the impacts in all three mentioned categories. Such actions aim to suppress the virus, minimising the length of the pandemic. With suppression as the policy, the overall resilience of a system is maximised, while risk to an individual is minimised.</p>			
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## 1 INTRODUCTION

Infectious diseases are the leading cause of deaths worldwide, causing a quarter to a third of all deaths. In the majority of developed countries, they are the third most common cause of deaths, after cancer and heart diseases. Despite developments in pharmaceuticals, rates of infectious disease are increasing due to urbanisation, increased travel, new diseases, irresponsible use of antibiotics and changes in human behaviour. (Verikios et al. 2011)

Pandemics have occurred throughout the history of mankind, and they have had profound social impacts, sometimes altering history (Bell & Lewis 2004). Research into their economic impact, however, has been limited until recent. As there has not been a severe global pandemic in a century, empirical data is very limited and outdated. This has resulted in models and estimates which appear to be very inaccurate in today's context. With the introduction of a new global pandemic in the winter of 2019-2020, the economic impact has become a relevant topic which deserves attention.

The current pandemic, a coronavirus causing a disease called COVID-19, has had the largest economic impact any pandemic or epidemic has had in the modern history. Previous estimates have used too optimistic assumptions, and the researchers have not fully understood how wide-spread consequences a pandemic outbreak can have. The length of the current pandemic remains to be seen, as well as the length of economic consequences caused by it. Most of the past research about the economic impacts of pandemics has claimed that economic impacts are largely short-term, except for the reduction in labour force caused by mortality. I suspect the current pandemic will cause at least medium-term effects, especially with the current way of handling the outbreak.

The purpose of this thesis is to provide a starting point for research into the economic effects of pandemics in general as well as the COVID-19 pandemic. This paper includes a large number of sources covering different fields. Historical pandemics and their economic effects are reviewed. This thesis also includes many studies about the economic effects of a potential pandemic, providing an overview of their results. Resilience and vulnerability, both important concepts in understanding the economic

effects of pandemics, are also explored. The impact of different policies when facing the current pandemic are also examined.

The next chapter of this thesis introduces the definition of epidemics and pandemics and goes through historical pandemics. Past studies of economic impacts of pandemics are used as source material. Third chapter focuses on the research into potential economic impacts of pandemics. I included several different studies and articles from the last two decades in an effort to build understanding about past research and obtained estimates. Focus in the third chapter is on the results, mathematical models included in the studies are not presented. If the reader is interested in the models or the theory behind them, more information can be found in the cited articles which are publicly available online.

Chapter 4 is about the concept of resilience to pandemics. Resilience and vulnerability are defined, and I introduce them in the context of pandemics. This is a very little researched subject, and I try to build the idea of resilience to pandemics based on literature about disaster and regional resilience. Chapter 5 gives an overview of the current coronavirus pandemic, focusing on the economic aspects. The impact on resilience of different policies is discussed. As the situation is new and evolving at the time of writing this thesis, majority of the sources are news articles and publications by authorities. Chapter 6 concludes this thesis. Findings and their policy implications are discussed, and some potential future research ideas are presented.

## 2 CASE EPIDEMICS AND PANDEMICS

### 2.1 About epidemics and pandemics

In order to talk about epidemics and pandemics throughout this paper, I need first to define their meaning. As the focus in this thesis is in economics, going too deep into medical terms is not necessary. I am simply adopting definitions used by Bloom and Canning in their paper *Epidemics and Economics*, which are originally from the World Health Organization and the US Centers for Disease Control and Prevention. They give the following definition for an epidemic:

“The occurrence in a community or region of cases of an illness, specific health-related behaviour, or other health-related events clearly in excess of normal expectancy. The community or region and the period in which the cases occur are specified precisely. The number of cases indicating the presence of an epidemic varies according to the agent, size, and type of population exposed; previous experience or lack of exposure to the disease; and time and place of occurrence...Generally, a disease that exhibits large inter-annual variability can be considered as epidemic. (World Health Organization)”

According to this definition, an epidemic is an unusually large amount of some health-related event occurring in a region. In this thesis epidemic refers always to some disease. Next, I give the definition for a pandemic used in the same source:

Pandemic: “An epidemic occurring over a very wide area (several countries or continents) and usually affecting a large proportion of the population. (US Centers for Disease Control and Prevention)”

A pandemic is simply an epidemic that occurs over a large geographical area, inflicting a substantial proportion of the population. (Bloom & Canning 2006)

Diseases, epidemics and pandemics have impacted humans always, and over 10 pandemics have been identified in the past 300 years (Jonung & Roeger 2006). Same diseases that circulate the world today can be seen in human remains from ancient Egypt. There are numerous documented epidemics and pandemics since ancient times, and these might have contributed even to the rise and fall of empires. For example, in the conquest of America by Europeans diseases had a huge role, as the American



population lacked immunity against European diseases. It is estimated that the population of Mexico declined from 28 million to 1,6 million in the century after the Spanish invasion due to repeated outbreaks of diseases. (Bell & Lewis 2004)

As pandemics cause such death in societies, they must have had significant social and economic consequences. The next part focuses on four past pandemics and their economic effects. Three of them happened in the modern era, and their economic consequences are particularly interesting.

## **2.2 Case diseases and their economic impacts**

### **2.2.1 The Black Death**

The most well-known historical pandemic, at least in the Western world, is the Black Death. It swept through Europe between 1347 and 1351, killing 25-35% of the population. It was caused by a bubonic plague spread by fleas living in rats and other rodents. Even in the medieval period Europe had a dense and active network of trade routes linking different areas of the continent, allowing the plague to spread rapidly. The plague devastated Europe: worst hit cities lost more than 3/4 of their population. (Bell & Lewis 2004)

It is easy to deduce that an event of this magnitude would have huge economic consequences to the regions it impacted. In a society that relied heavily on agriculture the price of land had been expensive, and the plague caused land prices to fall and the marginal cost of agricultural production to reduce. This combined with a significantly lower population lead to more plentiful food supplies. Labour shortages also provided more employment opportunities to those who survived. (Bell & Lewis 2004)

There has been some research into the economic effects of the Black Death, confirming the rise in real wages and a decrease in land rents. However, the return on capital declined. The direct long-term effect of the plague on Europe's production level was negligible. This could be partly explained by the recurring outbreaks of plague and wars, especially the Hundred Years War fought between France and England. (Bell & Lewis 2004)

### 2.2.2 The influenza pandemic of 1918

The influenza pandemic of 1918-1919, also often called the Spanish Flu, killed at least 40 million people worldwide from the spring of 1918 to the late spring of 1919. An estimated 25-30% of the world's population were infected, and up to 11% of the infected died. Even though it killed at least twice as many as the partly concurrent First World War, there has been very little research into its economic impact. In 2002, none of the leading textbooks of economic history mentioned the epidemic. (Brainerd & Siegler 2003) Perhaps the lack of research and literature regarding the Spanish Flu is explained by the First World War, which is thoroughly reviewed in the literature, including its economic impacts. The research that does exist focuses on the health effects and mortality differences between socioeconomic classes. (Garrett 2007)

Even though the pandemic was widely called the Spanish Flu, its origins remain unclear: suggested origins include Midwestern United States and China (Kilbourne 2006). The virus swept across the globe in three waves, the wave in the fall of 1918 being the deadliest (Bell & Lewis 2004). The global troop movements during the war and the demobilisation after it contributed greatly to the spread of the virus in a world where movement of people was usually on a much lower level (Garrett 2007). Even strictest quarantines did little in preventing the spread of the epidemic (Brainerd & Siegler 2003).

Of all the pandemics in the last 300 years, the 1918 pandemic seems to be the most severe, and it was easily the most severe in the 20<sup>th</sup> century (Arnold et al. 2005). Typical influenzas are usually dangerous for the very young and old, being less severe for healthy adults. The influenza of 1918 was unique in this regard: it was unusually deadly for population aged 18 to 40, and especially for men. The vulnerability of men is sometimes linked to the higher prevalence of latent tuberculosis, which can lead to more severe symptoms (Bell & Lewis 2004). One source from the United States reports that from a total of 272 500 male influenza deaths in 1918, 49% were 20-39 years old. (Garrett 2007)

Usually the age profile of mortality rates in influenzas is U-shaped, as the disease is deadliest for young children and the old. Most deaths in a typical influenza are caused

by a secondary bacterial infection leading to pneumonia (Arnold et al. 2005). In the influenza of 1918, the shape represented the letter W, as people in prime working age were affected unusually heavily (Brainerd & Siegler 2003). In this age group death was not usually caused by a pneumonia, but by a immunological overreaction to the virus, causing the individuals with the strongest immune systems to perish (Garrett 2007). Young and healthy individuals often died in less than 48 hours (Arnold et al. 2005).

Even though the economic effects of the 1918 influenza pandemic are little researched, it is clear that it was a large shock that had substantial macroeconomic effects (Brainerd & Siegler 2003). As the influenza killed a disproportionate amount of working age men, it reduced the labour supply and had a significant economic impact on businesses and families. The effect was amplified as the First World War had already killed a large amount of the same demographical group, especially in Europe. (Garrett 2007)

Brainerd and Siegler found that the epidemic in the United States was positively correlated with the following economic growth. They included the states for which data was available and concluded that a 0,1% increase in the death rate led to a 0,2% increase in the annual rate of economic growth for the next decade. However, they also found that business failure-rate was unusually high in 1919 and 1920, possibly due to deaths and economic effects of the pandemic. This means that the growth after the influenza is at least partly just a return to the trend. (Brainerd & Siegler 2003) There is also the possibility that the First World War had caused economic stress and limited investments during the war, and the ending of the war could have also caused a significant boost to the economic growth.

Most of the easily quantifiable microeconomic effects of the influenza were short-term. Businesses in the service and entertainment industry suffered double-digit revenue losses, but at the same time companies specialised in health care products and equipment experienced a period of growth. Some research suggests that a shortage of labour increased wages, at least for some time. (Garrett 2007)

Based on the available research, the overall economic effects of the influenza pandemic of 1918 seem to be relatively small. Economic data from the period of the pandemic is often either missing or distorted due to the First World War, which makes research difficult and inaccurate. Even though it had a massive scale and the influenza killed a disproportionate amount of working-age people, in the years after the pandemic there is very little evidence about negative impacts on economy.

### 2.2.3 The SARS epidemic of 2003

SARS, or severe acute respiratory syndrome, was the first deadly epidemic of the 21<sup>st</sup> century. After an initial outbreak in Guangdong, China, in November 2002, it quickly spread to at least 28 countries. The total number of cases reached 8 437 by July 2003, when the epidemic ended, and caused the death of 813 individuals. Regions that suffered the most were China and Hong Kong, with 348 and 298 deaths respectively. (Lee & Mckibbin 2004)

SARS was a new strain of coronavirus, it spread through droplets and caused pneumonia which could be fatal (Siu & Wong 2004). The case fatality rate was about 10%, and the emergence of the virus caused a lot of fear about a potential pandemic (Lee & Mckibbin 2004). Even though the virus was eventually contained, and the total number of killed was very low on global scale, SARS had significant economic impacts especially on the impacted areas (Bell & Lewis 2004).

The World Health Organization (WHO) issued a travel advisory urging people not to travel to Guangdong or Hong Kong on April 2, 2003. This devastated travel and tourism industries in the affected regions. In Hong Kong, the number of airline passengers fell by 77%, land travel dropped by 52% and travellers coming by sea declined by 72%. The occupancy rate in hotels dropped from 79% in early March to 18% in early May. (Siu & Wong 2004)

Even though SARS was a minor disease on global scale, it had large but short-term economic consequences. Some estimates put the cost of the virus at over 11 billion dollars. The economic consequences were caused by the strict measures taken to contain the epidemic and the uncertainty revolving around the epidemic. Modern and

global media coverage also helped to spread the fear and uncertainty (Bloom & Canning 2006). Fear of getting infected altered behaviour in the affected regions, reducing consumer demand (Lee & McKibbin 2004).

In Hong Kong the largest negative effects were on the demand side. As the residents were afraid of catching the virus, they started to avoid social interaction. Local consumption and export of services suffered heavy losses, the sales of restaurants and retail outlets dropped by 10-50%. Reduced demand and domestic consumption led to an increase in both unemployment and underemployment. (Siu & Wong 2004)

The stock market reaction to SARS was moderate. Between March 12th and April 30th, the Hang Seng Index of Hong Kong dropped by 1,78%. During the same period other indices continued to rise, except for the Taiwan Weighted Index and Japan's Nikkei 225. The SARS epidemic had no supply-side effects in Hong Kong, as the regions manufacturing base in the Pearl River Delta was unaffected and global supply chains were unaffected. There was also no negative impact on domestic or foreign investment. (Siu & Wong 2004)

The negative economic effects turned out to be short-lived, as the spread of the epidemic was successfully stopped. Tourism resumed, unemployment levels became lower and fear and panic subsided. The stock market quickly rebounded as the WHO declared the epidemic was over. (Siu & Wong 2004)

The SARS epidemic also caused governments of the impacted regions to act. Hong Kong launched a one-time relief package of 1,5 billion dollars to help companies survive the shock. Singapore offered 132 million dollars in relief to help affected businesses. Taiwan authorised 1,4 billion dollars to cover business losses and medical costs and ordered nearly a million people to quarantine in May. (Bell & Lewis 2004)

This was the first epidemic in the era of globalisation and modern markets, and it gave valuable insight about how pandemics could impact the economy. The economic consequences from a global disease are not limited only to the affected industries in the affected regions. As international trade and finance links have increased with

globalisation, an economic shock to one country is quickly spread to other countries (Lee & McKibbin 2004).

SARS is an important case in understanding the economic effects of an epidemic. It clearly demonstrated that the economic effects are not limited only to the costs of lost lives and healthcare, which were both low in the case of SARS. Most of the economic losses are caused by psychological factors; fear and uncertainty reduce demand and expectations about the future are re-evaluated. The SARS epidemic also set a precedent for government involvement in both controlling an epidemic and mitigating economic losses caused by it.

#### 2.2.4 The H1N1 pandemic of 2009

In May 2009, a new strain of H1N1 influenza emerged in Mexico. It is commonly known as the swine flu, as it is closely related to a pig influenza. It was highly infectious and spread to all six continents in five weeks. The virus spread more rapidly than expected, and WHO declared a pandemic on June 11, 2009. The virus spread to more than 200 countries, infecting hundreds of millions of people. (Verikios et al. 2011)

WHO confirmed over 18 000 fatalities by June 2010, but the amount of unconfirmed deaths may be significantly higher (Verikios et al. 2011). Centers for Disease Control and Prevention (CDC) estimated that the worldwide death toll for the first year of the pandemic ranged from 151 700 to 575 400. The virus affected primarily children and adults, with 80 percent of those who were killed by the disease under 65 years old. (Centers for Disease Controls and Prevention 2019)

The H1N1 virus proved to be a relatively mild strain of influenza, and efficient public health measures helped to stop the pandemic (Verikios et al. 2011). One study found the death rate to be just 0,026% (BBC 2009). Perhaps due to efficient public health measure and the low fatality rate of the virus, its economic effects are studied very little. One paper estimated the excess hospital admission costs in England totalled 45,3 million pounds between June 2009 and March 2011. Another research estimated that in Chile the pandemic lead to a loss of 16 million US dollars due to labour productivity

loss caused by missed days of work. Extrapolating the results to the United States, they estimated the cost of lost labour productivity there to be 2 billion US dollars. A 2013 paper estimated that due to the virus Mexico lost almost one million visitors, resulting in losses of around 2,8 billion US dollars to the tourism sector (Delivorias & Scholz 2020)

These historical epidemics and pandemics give some information about what kind of economic consequences a pandemic can have. Labour supply is decreased in long-term due to mortality, and in short-term due to illness. Health related costs increase during a pandemic. More recent cases, SARS and H1N1, clearly demonstrate the impact on tourism, travel, and the hospitality industry. SARS also showed how significant role psychological factors play, reducing demand and even impacting financial markets.

### **3 THE ECONOMIC IMPACT OF A POTENTIAL PANDEMIC**

#### **3.1 Past studies and estimates**

Numerous studies and reports have tried to quantify and predict the economic impacts of a possible pandemic outbreak. The methods and results vary a lot, depending on the expected characteristics of a new virus and the economic factors considered. Older papers, written before the SARS epidemic, tend to put a focus on the lost workdays due to illness and deaths. Newer studies generally try to include the effects of reduced economic activity and psychological factors. Some studies even consider the value of lost human lives (Fan et al. 2018).

The research however has been highly speculative, as there has not been a significant pandemic in a hundred years, and the world has changed a lot since then. Without empirical data and knowledge, researchers have had to use rough estimates for many factors. The models are sensitive to the estimated infection rate and mortality, used values have been mostly guesses about the true numbers of past epidemics.

A study conducted in 2005 by the United States Congressional Budget Office considered two separate pandemic scenarios and their effects in the United States. First scenario resembles the 1918 influenza pandemic, with 90 million people getting the disease and 2 million of them dying, with a 2,5% case fatality rate. In the second and milder scenario 75 million people are infected and 100 000 of them die, case fatality rate being around 0,1%. (Arnold et al. 2005)

The scenarios included declines in short-term demand and supply, shrinking of labour supply, and a drop in the long-term supply. A lot of assumptions were made. In short-term, a surge in demand for health services was assumed. International travel was expected decline dramatically, but not completely. Nonessential activities requiring social interaction were expected to decrease significantly, including cultural events and going to restaurants. During a severe pandemic the health system would be overwhelmed, and health care workers would suffer disproportionately leading to further strain on health care. (Arnold et al. 2005)



Business confidence would falter, supply chains would be affected, and the stock market would fall for the period of the outbreak. The actions of governments would both mitigate and increase the negative effects. Enforced travel restrictions and quarantines would increase the economic impacts, but they would reduce the human toll and give time to develop a vaccine. (Arnold et al. 2005)

The authors give rough estimates for both demand and supply-side effects in both scenarios, reminding the reader that the estimates give the cost of a potential pandemic, and not what a society would be willing to pay to prevent a pandemic and numerous deaths. In the severe scenario, the negative demand-side effects would be around 2% of the gross domestic product (GDP), and supply-side effects 2,25%, giving a total GDP reduction of 4,25% in the year of the pandemic. The mild scenario would yield much smaller economic consequences, indistinguishable from normal economic volatility. The negative impact to both demand and supply would be 0,5% of the GDP, for a total reduction of 1%. This means that the GDP would likely continue to grow in the year of the mild pandemic. (Arnold et al. 2005)

Long-term impact of a pandemic would be the reduction in labour force caused by excess mortality. This would depend greatly on the mortality rate and which age group the disease affects the most. If a large proportion of those who are killed are of working age, the economic impacts are magnified. Pandemic that affects mostly older people would not have such a large impact on the total labour force. (Arnold et al. 2005)

In the study the authors admit that due to the lack of empirical evidence and estimates, calculating the effects of a pandemic is extremely hard. A clear lack in the study is that the authors do not consider potential unemployment caused by a pandemic. They also do not assess the possibility of increased business failures. The assumed declines in demand are also quite small, especially in the mild scenario. In the mild scenario, air transport is expected to decline by 17% and accommodation by 20%. Demand for other services declines by 1%. Finance sector is unaffected in both scenarios, even though the authors think the stock market would temporarily fall during a pandemic. (Arnold et al. 2005)

European Commission published a similar study in 2006, estimating the potential macroeconomic consequences of a pandemic in Europe. They concluded that even though a pandemic would cause a lot of suffering, the macroeconomic impacts would likely not be severe. Three important factors used in the modelling are the morbidity rate (infection rate), number of work weeks lost and mortality rate. In their calculations using a New Keynesian macro-economic model, they adopt the severe scenario from the previously mentioned study conducted by the United States Congressional Budget Office. (Jonung & Roeger 2006)

The pandemic is assumed to last only one quarter, with morbidity rate being 30% and mortality rate 2,5%. Number of weeks off work due to the pandemic is estimated to be 3 weeks. In the base model, the effect of reduced demand causes a 0,5% drop to the GDP growth in the year when the pandemic occurs. The negative supply-side effect is 1,1%. In total, the GDP *growth* is expected to slow down by 1,6%. Mediterranean countries would be hit the hardest, due to their large tourism sector. (Jonung & Roeger 2006)

The authors did also study additional scenarios. When the role of psychological factors, causing a larger reduction in demand, were increased, the GDP loss increased to 3,3%. Share prices falling by 10% would increase the loss by an additional 0,2-0,8%. If the pandemic would last two quarters instead of just one, the GDP would be reduced by 2,6%. Adding only these additional reductions together, the GDP growth of EU would drop by 6,1-6,7% in the year of the pandemic. There would also be additional losses if the pandemic happened during summer, when the tourism sector is the most active. The authors conclude that even a pandemic that would cause higher mortality than the influenza pandemic of 1918 would not spell disaster for the economy of Europe. The estimated impact is roughly the same as of a major recession. (Jonung & Roeger 2006)

In a 2006 paper by McKibbin and Sidarenko, four different scenarios are considered: mild, moderate, severe and ultra. Each scenario includes shocks to the labour force caused by deaths and illnesses, supply shocks, demand shocks and risk premium shocks. The authors give the decrease in the global GDP only for mild and ultra scenarios, and they do not give assumptions about the severity of each scenario in an

easy-to-read form. The global GDP decrease is estimated to range from 0,8% in the mild scenario to 12,6% in the ultra scenario. They assume the economy of North America and Europe would not be impacted as much, and equity markets would fall, but only a little. (Mckibbin et al. 2006)

A short paper by Burns et al. published in 2008 considered a pandemic similar to the 1918 pandemic. They assumed air travel, tourism, restaurant sales and consumption of public transport services would decline by 20%. Total mortality of population varies between regions, from 0,3% in the United States to over 2% in certain developing countries. In their model, the total impact to global GDP would be -3,1%. This includes reductions from mortality (-0,4%), illness and absenteeism from work (-0,9%) and efforts to avoid infection (-1,9%). The authors remark the assumptions about decline in demand are low compared to declines witnessed during the SARS epidemic, and actual number could be very different. (Burns et al. 2008)

Verikios et al., in a 2011 paper, also considered two separate pandemic scenarios: a virus with a low infection rate (3%) but a high case fatality rate (10%), and a virus with a high infection rate (40%) but a low case fatality rate (0,5%). These numbers represent a situation where there is no treatment or restrictions on movement. Their main findings were that a virus with a high infection rate, but a low case fatality rate, would have larger economic consequences. The effects would be amplified in regions that are more globally integrated. (Verikios et al. 2011)

In modelling, the authors used a modified version of GTAP suitable for dynamic events. GTAP is a multi-regional, comparative-static, computable general equilibrium model. It includes world trade and investment, representing markets as perfectly competitive and traded goods as imperfectly substitutable. In simulating the economic effects of a pandemic, they included four different shocks:

- 1) An increase in demand for hospital and other medical services.
- 2) Temporary reduction in the labour force, due to sick leaves and school closures requiring parents to stay home.
- 3) Permanent reduction in the labour force caused by deaths.

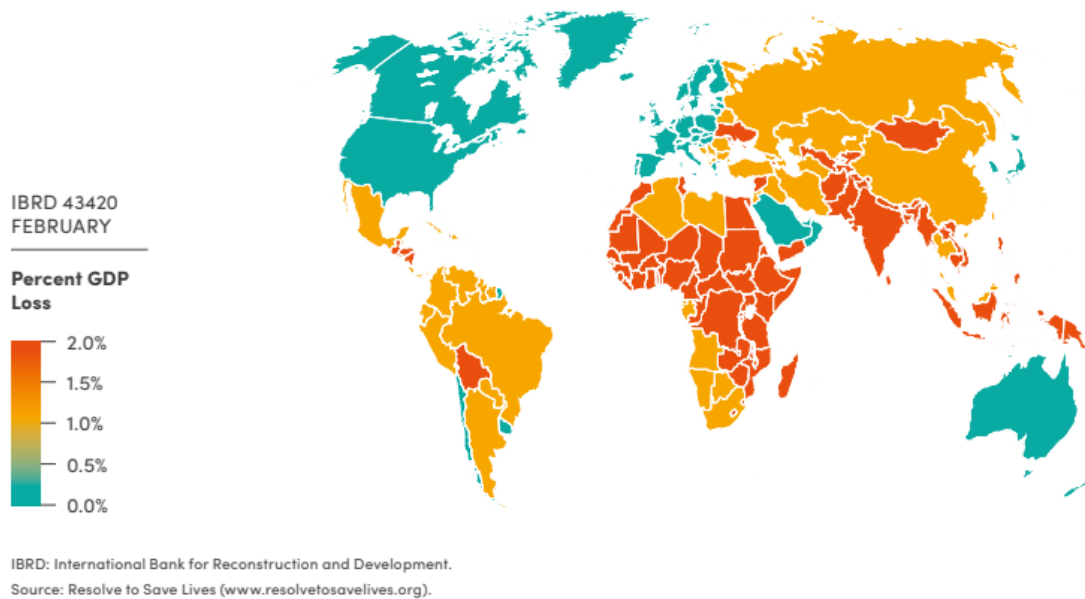
- 4) Temporary reduction in international tourism and business travel. (Verikios et al. 2011)

In the scenario with a high case fatality but a low infection rate, effect on the global GDP in the year the pandemic occurs is -0,27%. When looking at quarterly numbers, the effects are highest in the second quarter of the epidemic: GDP is -0,3% below baseline and employment -0,32% below baseline. Global economy starts to recover in the fourth quarter following the initial outbreak, and the recovery takes a year. (Verikios et al. 2011)

In the scenario with a low case fatality but a high infection rate, effect on the global GDP in the year the pandemic occurs is -3,34%. When looking at quarterly numbers, the effects are again highest in the second quarter of the epidemic. GDP is -4,5% below baseline and employment -6,4% below baseline. Global economy starts to recover in the fourth quarter following the initial outbreak, and the recovery takes a year. The global GDP and employment stay above baseline for several years following the recovery. (Verikios et al. 2011)

The results obtained by the authors additionally demonstrate that economies are affected not only by how the pandemic situation evolves within their own country, but also by how other areas and global trade are affected. As a result, economies relying heavily on tourism and international trade will be more heavily affected by a potential epidemic. (Verikios et al. 2011)

The World Bank estimates that a global influenza pandemic similar to the 1918 pandemic could cost the global economy 3 trillion US dollars, which is 4,8% of the GDP. Even a less severe, moderate influenza pandemic would cost 2,2% of the global GDP. Figure 1 illustrates the vulnerability of different countries to pandemics. The International Monetary Fund's threshold for a major economic disaster is a loss of 0,5% in the GDP. (Global Preparedness Monitoring Board 2019)



**Figure 1. Economic vulnerability of countries to pandemics in terms of GDP loss (Global Preparedness Monitoring Board, 2019. Licence: CC BY-NC-SA 3.0 IGO).**

### 3.2 Summary

It is clear that pandemics have significant economic consequences. Trying to quantify or model the economic impact has been very difficult, as there are no benchmarking events in recent history. Uncertainty about the biological characteristics of a potential pandemic, including length, infection rate and case fatality rate obviously impact estimates a lot. The number of different factors included in the estimates is also important.

Most of the estimates include the temporary and permanent reductions in the labour supply caused by a pandemic. Permanent reduction is naturally caused by deaths and depends to some degree on the demographic group the pandemic affects the most. Temporary reduction in most studies is defined by those who are ill and those who are forced to stay at home. Of course, there is also the chance that healthy individuals cannot work due to restrictions on movement or businesses, and this is largely unexplored in the studies I have examined. Potential unemployment caused by a pandemic is also largely unaccounted for.

Pandemics have obvious impacts to the demand and supply, but the expected reductions vary greatly between studies. Most agree that service industry and travel industry are the most affected, due to fear and travel restrictions. I found most of the estimated reductions in different industries to be very optimistic, and the numbers were not based on empirical evidence, except for tourism and air travel in the newer studies.

Psychological effects were included in some of the studies and including them generally gave much higher estimates. Fear and expectations alter the behaviour of both individuals and businesses, and even a mild epidemic can reduce demand a lot. Uncertainty, especially in the early stages of a pandemic, can also reduce risky behaviour of all market participants. It is possible that investments are reassessed and share prices become volatile as the future becomes uncertain. The potential impact of uncertainty in the financial markets was also largely neglected in these studies.

Analysing the potential economic impacts of a pandemic is and will be difficult, as pandemics are a rare event. Each one is also unique, they have different qualities, spread around the world with a different pace and have very different economic impacts. Creating an accurate and general model for estimating the economic impacts of pandemics is therefore likely impossible. It is more important to understand the different ways a pandemic can impact the economy.

Table 1 summarises the estimates. Most of the estimated impacts to GDP are quite small, ranging from almost zero to around -5%. Only the ultra scenario in the paper by McKibbin and Sidarenko gives a figure that is higher than 5%.

**Table 1. Estimated economic impacts of a pandemic, as a percentage of GDP (partially adapted from Jonung & Roeger, 2006).**

Country/region	Author	Range of estimates
EU-25	Jonung & Roeger (2006)	1,6 - 4,1%
USA	Arnold et al. (2005)	1,0 - 4,25%
Canada	James & Sargent (2006)	0,2 - 1,0%
Germany	FT Deutschland (2006)	1,1 - 3,3%
World	McKibbin & Sidorenko (2006)	0,8 - 12,6%
World	Burns et al. (2008)	3,1%
World	Verikios et al. (2011)	0,27 - 3,3%
World	Global Preparedness Monitoring Board (2019)	2,2 – 4,8%

## 4 RESILIENCE AND PANDEMICS

### 4.1 The concept of resilience

The word resilience comes from the Latin word *resilire*, which means leaping back or rebounding. It refers to the ability to recover from a disturbance or disruption. The concept of resilience has been used for some time in numerous scientific fields, such as ecological sciences and engineering. (Martin 2012)

First to use the term were ecologists in the 1970s, when it was defined as “the ability of systems to absorb changes ... and still persist”. Since then the use of the term has spread to many scientific fields, including economics. Research of resilience to short-term disasters started in the 1990s, and limited study into the economic effects of disasters in the 2000s. (Rose 2009)

The term resilience still lacks a uniform definition, maybe because it is applied in several different fields and situations. There are many different definitions for resilience from different fields, but I will mention only two relevant ones. It must be noted that I could not find a written definition for resilience to pandemics or epidemics.

From the literature of disaster resilience, the following definition of resilience mentioned by Cutter et al. (2008) can be used in the context of pandemics:

“a community or region’s capability to prepare for, respond to, and recover from significant disturbance-driven changes: while maintaining community character, cohesion and capacity, and without permanent impairment of the community’s public safety and health, economic, social, and national security functions, thus, accelerating recovery.”

This definition is clearly related to the resilience of a community, and it only briefly mentions the economic aspects of resilience. But maintaining economic and social functions during a pandemic is obviously important for the resilience of any region or country.



Hill et al. (2008) define regional economic resilience as “the ability of a region to recover successfully from shocks to its economy that either throw it off its growth path or have the potential to throw it off its growth path but do not actually do so”. Regions can be thrown off their growth path by either a structural change or an external shock. Negative shocks can cause three different responses in a region. If the economy of a region is not impacted by a shock, it is called shock resistant. Regions that rebound quickly are called economically resilient. Those regions that are unable to return their previous growth path are non-resilient. (Hill et al. 2008)

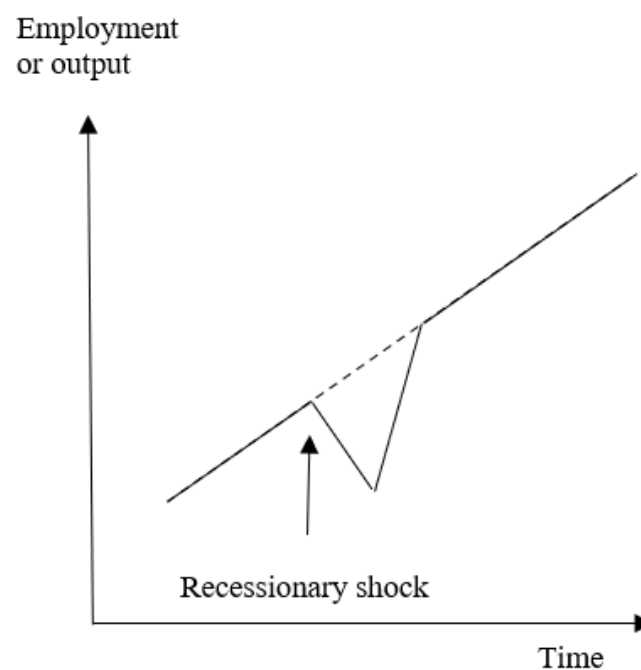
Economic resilience can also be divided into static and dynamic resilience. Static economic resilience is the inherent ability of a system to maintain economic functions when shocked. It is existing prior to the shock and includes for example inventories and emergency plans. Dynamic economic resilience is the recovery speed of a system from a severe shock. This adaptive form of resilience refers to the adaptation to new situation caused by a negative shock. (Rose 2009)

Martin, in his 2012 paper, explores the concept of regional economic resilience from multiple perspectives and tries to develop the idea further. He introduces three different interpretations of regional economic resilience, these are engineering resilience, ecological resilience and adaptive resilience. Martin also gives us four different dimensions of regional resilience, these are resistance, recovery, re-orientation and renewal. I will focus on these interpretations and dimensions in the following chapters. (Martin 2012)

#### 4.1.1 Engineering resilience

Engineering resilience has its root in physical sciences. It focuses on the resistance of a system; this refers to the ability to withstand and recover from shocks. A more shock-resistant system has a smaller initial reaction to a shock and recovers from it faster and is therefore more resilient. In the context of regional resilience, a resilient region rebounds faster to its original growth path following the shock. A region with low resilience is impacted more by the initial shock, and the recovery takes longer. (Martin 2012)

The focus of the engineering interpretation is on the stability of a system or a region near its equilibrium. The economy is assumed to be self-equilibrating: shocks that move the economy away from its equilibrium activate automatic compensating adjustments, which operate until the economy is back in the equilibrium. The time of recovery may vary, based on how quickly the adjustments start to affect, but the economy will return to the pre-shock equilibrium. This is illustrated in figure 2. (Martin 2012)



**Figure 2. Impact of a shock on a region's growth path. Adapted from Martin (2012).**

#### 4.1.2 Ecological resilience

Ecological resilience focuses on the elasticity threshold of a system. Each system has a certain amount of disturbances or shocks it can absorb before these events push the system beyond its elasticity threshold. When the threshold is reached, the system changes form, function or position. Resilience is measured by the amount of disturbances a system can withstand before reaching the elasticity threshold. (Martin 2012)

In the context of regional economic resilience, reaching the elasticity threshold can have two different results. The resulting change can have a positive impact on the

region's economy, leading to a state that is better than the pre-change state. Such a region has high resilience. If the impact is negative, and the following state is inferior to the pre-change state, the region has low resilience. (Martin 2012)

This leads us to the concept of *hysteresis*. Romer (2001) defines it as an event “where one-time disturbances permanently affect the path of the economy”. For example, a recession can permanently change the industrial structure of a region, and the new growth path will be different. Destruction of businesses and increased unemployment might cause a permanent contraction to a region's economy. Such a region has low resilience. There may also be positive effects caused by a shock, and the new growth path will be higher than before the shock. A recession may destroy old and ineffective structures, companies and policies, leading to beneficial reforms and new innovative businesses. A region that moves to a higher growth-path following a shock or disturbance has high resilience. (Martin 2012)

#### 4.1.3 Adaptive resilience

The roots of this interpretation are in the theory of adaptive systems. An adaptive system has a capacity to rearrange its internal structure spontaneously when facing an external shock or internal issues. In the context of regional resilience, a resilient region has the capacity to reconfigure its structure when facing external or internal shocks or disruptions. A resilient region can maintain a good growth path, with for example high rates of entrepreneurship and firm formation, innovativeness, willingness to move beyond current sector and the diversity of economic structure. (Martin 2012)

This interpretation views resilience as a dynamic progress, which is always evolving. A region with has high level of adaptive resilience continuously replaces outdated and unproductive activities and businesses with new structures, companies and innovations. An external shock, such as a recession, accelerates this progress. The impacts of a recession, both negative and positive, are different for different regions and for example the pre-existing industrial structure has an effect. A region where the positive adaptation effects outweigh the negative shock effects is resilient. (Martin 2012)

#### 4.1.4 The dimensions of regional resilience

Martin suggests that there are at least four different dimensions of regional resilience, which are all interconnected. First of these dimensions is *resistance*, which refers to a region's vulnerability and sensitivity to disturbances and disruptions. These include for example recessionary shocks. *Recovery* is about the speed and extent a region recovers from a shock. The third dimension concerns the extent of structural *re-orientation* of a region, and how the associated changes impact the region's economy. The fourth dimension, *renewal*, concerns the degree of a regions' resumption to the pre-shock growth path. (Martin 2012)

#### 4.1.5 The role of industrial structure

The industrial structure plays a large role in the resilience of a region. The more diversified the industrial structure is, the better a region's resistance to shocks is. The analogy is largely the same as for a diversified investment portfolio – the risk of an industry-specific shock becomes smaller when the number of industries goes up. The industries should not be closely linked to each other, or in investing terms their correlation when facing certain shocks should be low. Specialising in only one industry is risky for a region in the same way investing in only one company is. There are however positive externalities associated with specialisation, so the solution for the optimal industrial structure is likely not just maximised diversity. (Simonen et al. 2020)

Specialising in one industry does not automatically lead to regional economic problems when facing a negative shock. If the shock hits only some specific industry, the probability that it hits the specific industry a region is specialised in is low. A shock that impacts the whole economy nullifies the benefits of a diversified industrial structure. Some industries also are naturally more resilient than others, limiting the risk of specialisation. Martin also claims in his 2016 paper that the overall importance of economic structure is limited. The specific competitive qualities of a region play a larger role in how regions react to and recover from economic shocks. (Martin et al. 2016)

## 4.2 Regional economic resilience and pandemics

The theories and concepts of regional economic resilience can also be used when considering resilience against pandemics. Resilience to epidemics or pandemics can be applied to individuals, businesses, regions or countries. Even the global resilience to pandemics could be considered. Literature about economic resilience to epidemics and pandemics is largely non-existent, I was able to find only one article related directly to it. There is literature about resilience to disasters, both natural and man-made. Some of the analogy of resilience to disasters is easily applied to the context of epidemics and pandemics, as they are natural disasters.

When considering economic resilience facing a disaster such as a pandemic, it is important to take time into account. As the pandemic becomes prolonged, resilience starts to erode. Inventories start to deplete as mobility is limited and supply chains start to suffer, which causes damage to businesses relying on inventories. Individuals whose mobility is restricted spend less money. As the resilience continues to decrease, it becomes increasingly harder to implement actions that would improve the resilience of a system. As time goes on and businesses and industries suffer and potentially fail, a domino effect starts. (Rose 2009)

Pandemics can have major effects on resilience, depending on the magnitude and duration of the pandemic. It is of course impossible to know how long the outbreak and its consequences last. Pandemics can challenge individual businesses and the economy as a whole, and due to this enhancing resilience with proper preparation is desirable. Individuals can also increase their personal resilience by preparing for a potential pandemic. They can also help the economic resilience in a pandemic situation by supporting businesses with continued consumption. (Rose 2009)

Resilience to pandemics is a very underresearched subject and deserves more attention. As we are currently experiencing the most serious pandemic in a century, resilience to pandemics is an interesting and important topic. I am sure there will be many studies about resilience after the pandemic from several different perspectives. Future studies should consider which variables to include and how to measure for example a country's resilience and vulnerability to pandemics. It is obvious that some countries

are more vulnerable than others, and not all countries are equally resilient to pandemics.

There are many factors that can contribute to vulnerability against pandemics. These include for example population density and the extent of transportation network. Regions that rely on the economic sectors that are most affected, for example tourism, are more vulnerable to suffer from a pandemic. Their recovery is also slower. This means that the industrial structure plays an important role in defining the resilience and vulnerability of a region. There are also demographic, social and cultural characteristics that add to vulnerability. Age and health of the population is a big factor in how many deaths a pandemic can potentially inflict. Social and cultural differences between countries and regions, such as the level of intimacy and attitudes towards preventive measures, also play a big role. (Cutter et al. 2008)

As the mobility is reduced, rich countries where working and studying from home is possible are better equipped to keep the society running. They are also likely to have better infrastructure and health care. Rich countries are also likely to be better prepared for a pandemic and they have more options to deal with the crisis. Social safety nets are also known to be more extensive in developed countries. Developed countries, however, are often more globally linked. This increases the risks that an epidemic in some other part of the world has an impact on these countries. Small countries with small domestic markets and a reliance on international trade are especially vulnerable.

### **4.3 Resilience management during a pandemic**

Massaro et al. (2018) studied societies' resilience during epidemics, and how different policies impact the resilience. In their research they considered the impact of an epidemic on society's economy, infrastructure and service disruption. Both theoretical and data-driven methods were used. They combined the attack rate of disease, that is the chance for an individual to catch the disease, with human mobility deterioration caused by a disruption to the systems functionality. Their main finding was that interventions to contain an epidemic, such as travel restrictions and quarantines, may have a negative impact on a society, as they reduce resilience and lead to a slower recovery. (Massaro et al. 2018)

They considered many aspects in their study of resilience, including societal aspects like infrastructure and service disruption, and economic aspects such as forgone output and fiscal deficits caused by a crisis and poverty. Their study had a temporal dimension to analyse the recovery of a society. They simulated the spread of an infectious disease in connected populations and monitored the system-level response caused by the prevalence of the disease, restricted travel and social distancing. While intervention strategies reduce the risk for an individual to catch a disease, they progressively degrade the system's functionality and resilience by degrading mobility. (Massaro et al. 2018)

Important factor that mitigates the spread of an epidemic is the behavioural change in the population, caused by fear and awareness of the disease, and even the fear and awareness of others. Examples of such behaviour changes are working from home, decreased travel and avoidance of public. In addition to self-initiated social isolation there may be mandatory travel limitations further deteriorating the system's functionality. When there are fewer human interactions, naturally the epidemic does not transfer as efficiently, and the spreading slows down. (Massaro et al. 2018)

In their model, at time  $t$ , system-wide critical functionality  $CF(t)$  is defined as a function of the disruption to the system's functionality caused by reduced human mobility and the risk for an individual to get the disease. It is simply the product of the fraction of active travellers  $A(t)$  and the fraction of healthy population  $H(t)$ . Resilience  $r$  is defined as the integral over time of the critical functionality, normalized over the control time  $T_c$  and it is given by the following function (Massaro et al. 2018):

$$r = \frac{1}{T_c} \int_0^{T_c} CF(t) dt.$$

The critical functionality is calculated in a very simple way, containing only two components which are equally weighted. A more complex model could include several different components. These could include:

- 1) Details concerning the spread of the disease, such as mortality, infectiousness, recovery time and possible residual immunity obtained from other diseases.

- 2) Preparedness, including the availability of vaccines, hospital capacity and pharmaceuticals.
- 3) The socioeconomical costs caused by an outbreak and interventions, for example school closures, travel bans and quarantines.
- 4) Politics, media and the public perception of risk. (Massaro et al. 2018)

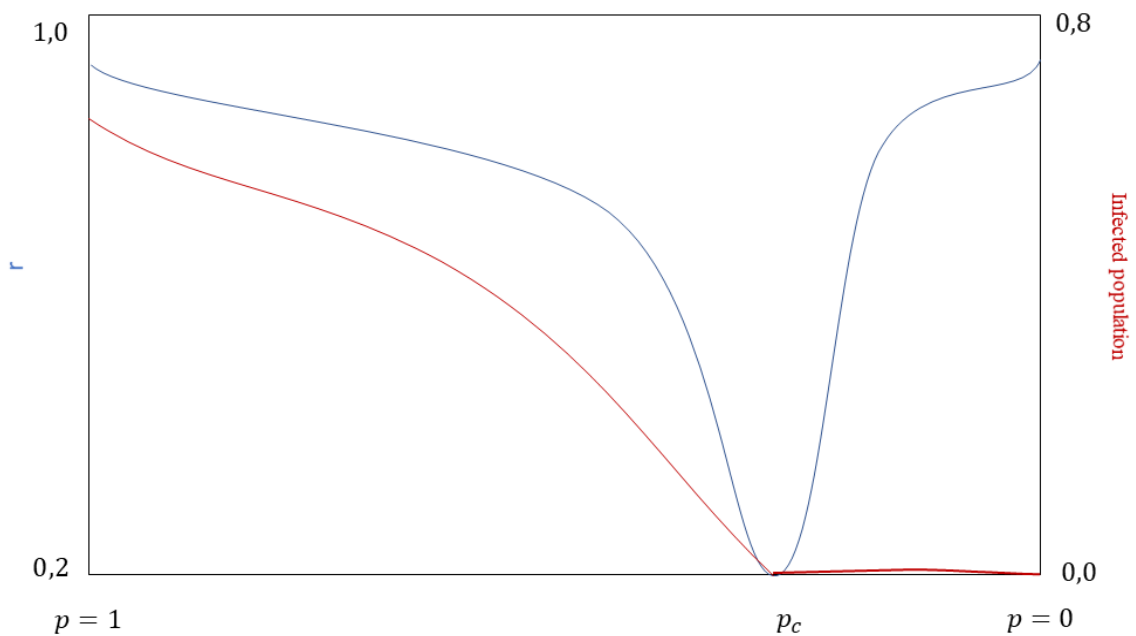
The purpose of measures that restrict human mobility is to stop the epidemic from spreading to new areas, which are not yet affected by the disease. However, they have a significant impact on the economy and impact the delivery of services, including medical supplies and specialised personnel. Travel restrictions have significant costs, and before implementing their costs and benefits should be considered thoroughly. (Massaro et al. 2018)

The authors define a global invasion threshold  $R_*$  as a function of the inherent reproduction number of a disease,  $R_0$ , and the mobility parameter  $p$ . Under no travel restrictions, we have  $p = 1$ . When  $R_* \geq 1$ , the epidemic is spreading and multiplying, and therefore continuing to stay in the system. When limiting mobility, the purpose is to achieve a level of mobility that keeps the global invasion threshold from reaching one. The critical level of mobility  $p$ , when  $R_* = 1$ , is denoted as  $p_c$ . (Massaro et al. 2018)

From a risk perspective, the best strategy in an epidemic outbreak is to restrict movement as much as possible, as the attack rate of the disease falls when the value of  $p$  becomes lower. From the perspective of overall resilience, the story is different. While risk decreases when mobility is restricted and the value of  $p$  starts to go down from 1, resilience also starts to decrease. Resilience finally starts to increase when  $p = p_c$ , as the epidemic is under control. (Massaro et al. 2018)



The reason why resilience decreases when mobility is reduced is mainly due to the critical slowing of the epidemic spreading near the invasion threshold. When the value of  $p$  becomes lower, the spreading of the disease slows. The spread becomes increasingly slower when  $p$  approaches  $p_c$ , but as the value of  $R_* \geq 1$ , the epidemic continues to spread. As the spread of the epidemic slows down, the risk becomes lower, but because the system must stay in a state of deteriorated functionality due to compromised mobility, its resilience suffers. The minimum resilience exists at the point where  $R_* = 1$ , as the length of the epidemic is maximised. This is illustrated in figure 2. (Massaro et al. 2018)



**Figure 3. Resilience ( $r$ ) and the fraction of infected population with different values of  $p$ . Figure is only illustrative. Adapted from Massaro et al. (2018).**

Another factor contributing to the spread of an epidemic is the amount of self-initiated behavioural change in a system. An individual changes behaviour when he fears catching a disease, and the fear can be increased for example by media coverage or the actions of other individuals. The number of individuals who choose to avoid risky situations by reducing movement has a similar impact to the spread of the epidemic as travel restrictions. The higher the fraction of individuals limiting their risky behaviour,

the lower the overall risk. When the fraction increases, resilience reduces. (Massaro et al. 2018)

When implementing travel restrictions and limiting mobility in other ways, there should be a thorough cost-benefit analysis. It is also an ethical question, as not reducing travel likely leads to excess deaths and human suffering. On the other hand, setting too harsh travel restrictions compromises system's resilience for a long period. As new epidemics emerge and information is imperfect, the natural reaction is to manage risk conservatively and limit travel. Methods such as quarantines and travel bans should be analysed well before implementing, as they may be burdensome and ineffective. (Massaro et al. 2018)

Data-driven simulations also prove the theoretical models. With travel restrictions and self-initiated behaviour included, three different regimes are found:

- 1) With low travel reduction, a very severe epidemic spreads fast throughout the system, but due to the short duration the system goes back to normal quickly. Resilience is high.
- 2) When the amount of travel reduction is close to the global invasion threshold, risk is low, and a small fraction of the population gets the disease. System critical functionality, however, is compromised for a long time and the resilience is low.
- 3) Travel is reduced enough to keep the epidemic from reaching global invasion threshold, and it does not spread. Risk is low and resilience is high.

In the data-driven model, the required mobility level to stop the epidemic is extremely low. It is reached only with very severe travel restrictions, which are practically impossible to maintain with modern transportation networks. In practice, limiting mobility by travel restrictions or self-initiated behaviour always results in lower resilience but reduced risk. (Massaro et al. 2018)

## 5 THE CORONAVIRUS PANDEMIC OF 2020 (COVID-19)

On December 31st, 2019, Chinese authorities informed WHO of a new strain of coronavirus that had not been previously detected in humans. The virus was first detected in Wuhan, China, and likely originated in animals, possibly bats or pangolins, from which it jumped to humans. This new strain of coronavirus, SARS-CoV-2, causes a disease called COVID-19. (Andersen et al. 2020)

The virus is transmitted via respiratory droplets, and incubation period ranges from 2 to 14 days. Symptoms range from mild to severe. Mild symptoms include fever, cough, shortness of breath, tiredness and muscle pain. Severe symptoms include pneumonia, acute respiratory distress syndrome, septic shock and sepsis. These symptoms can be fatal, and as of April 2020 there is no cure or vaccine. (Delivorias & Scholz 2020)

Most of those who are infected develop a mild to moderate respiratory illness, and do not require special medical treatment. Older people, or those with underlying medical problems, are particularly vulnerable to develop a serious illness. These underlying conditions include cardiovascular or respiratory diseases, diabetes, obesity and cancer. (World Health Organization 2020)

At the moment of writing this thesis, a lot of information about the virus was still unknown or uncertain. On April 13, 2020, the current case fatality rate of confirmed cases is 6,17% with 1,85 million confirmed cases and 114 300 deaths (John Hopkins University 2020). The case fatality differs a lot between countries, from 0,35% in Israel to 11% in Italy. Variation in fatality rates between countries is likely explained by differences in testing: countries that test only severe cases naturally have higher statistical death rates. As the virus can be asymptomatic, and most of the mild cases go unnoticed, the real fatality rate is likely much lower. (BBC Future 2020)

One study, using data from mainland China, estimated the crude case fatality rate to be 3,67%, after adjusting for censoring. The same study estimated the total illness fatality rate to be 0,66% in mainland China. This number includes undiagnosed cases and gives a better picture about the overall severity of the disease. The fatality rate rises quickly in the category of over 60-year olds. For the age category 60-69, infection

fatality rate was estimated to be 1,93%, and for individuals over 80 years the estimate was 7,80%. (Verity et al. 2020)

### **5.1 Timeline in 2020, until April 15<sup>th</sup>.**

- January 7. Chinese authorities identify the virus.
- January 11. First reported death in China.
- January 13. First recorded case outside China.
- January 23. Wuhan, a city of over 11 million people, is placed under quarantine. Whole province of Hubei follows soon after.
- January 30. The WHO declares a global emergency.
- February 1. Global confirmed cases reach 10 000.
- February 2. First recorded death outside China.
- February 10. Global confirmed deaths reach 1 000.
- February 14. First recorded death in Europe.
- February 19. Outbreak begins in Iran.
- February 21. Outbreak begins in Italy.
- February 29. First recorded death in USA.
- March 3. Outbreak begins in Spain.
- March 6. Global confirmed cases reach 100 000.
- March 8. Nation-wide lockdown starts in Italy.
- March 11. The WHO declares the outbreak a pandemic, USA bans all travel from 26 European countries.
- March 13. National emergency is declared in USA.
- March 17. Nation-wide lockdown begins in France. The European Union closes outer borders.
- March 19. Global confirmed deaths reach 10 000.
- March 23. Nation-wide lockdown begins in the UK.
- March 24. Nation-wide lockdown begins in India.
- March 31. More than a third of humanity is under some kind of lockdown.
- April 2. Global confirmed cases reach 1 000 000.
- April 10. Global confirmed deaths reach 100 000.
- April 13. Some European countries start to ease restrictions.

Case statistics are retrieved from a John Hopkins University coronavirus tracking website (John Hopkins University 2020). Death statistics come from graphs available at Worldometer (Worldometer 2020). Other parts of the timeline are compiled from articles by The New York Times (The New York Times 2020b) and Business Insider (Business Insider 2020).

## **5.2 The economic effects**

As the pandemic is an ongoing effect at the moment of writing, the economic impacts are still not fully realised. New information is gained almost daily, and estimates change from week to week. As the economic effects are spreading slowly to more and more industries and regions, trying to paint a clear picture of the situation is difficult. Information is often already outdated when it is published, and the current and future impacts are not yet known. In this chapter I go through the impacts caused by the pandemic in chosen categories, with the information and estimates that are currently available.

Even though the pandemic is still likely in its early stages, it is already safe to say it has had the largest impact on economy out of all the pandemics that have occurred in the last centuries. Globalisation and increased travel have increased the potential for the pandemic and its economic effects to spread quickly throughout the world. COVID-19 has also delivered an unexpected, extremely fast and large shock to the global economies as governments have implemented restrictions. Some economic figures, such as the growth speed of unemployment, are unprecedented.

This chapter is written in the beginning of April 2020. Older studies trying to model the potential economic impacts of a pandemic have already proved to be too optimistic, at least for a pandemic with a mortality as low as COVID-19. I begin this chapter by including a very recent study, which also seems very optimistic, to demonstrate how quickly expectations have been changing.

### 5.2.1 An early study

Mckibbin and Fernando published an article in the beginning of March 2020, when the pandemic was starting to really spread globally, about the potential economic effects of the coronavirus. They simulated seven different scenarios, of which four assumed the disease would spread into a global pandemic. I will focus on the results of these scenarios, excluding a scenario where it is assumed that coronavirus would return every year in the future. First of these three scenarios assumes that 10% of population gets the disease in China, and case fatality in China is 2%. Second scenario has a 20% attack rate and 2,5% case fatality rate. Third scenario has a 30% attack rate and 3% case fatality rate. Case fatality rate and attack rate for other countries are calculated with a vulnerability index, in practice a percentage of the values for China. A large proportion of this index consists of spending on health care, which is the highest in the USA. (Mckibbin & Fernando 2020)

In the first scenario, the estimated negative shock to consumption demand is around 1% for all regions. Negative shock to labour supply is estimated to be 0,4-1,4% depending on region, with Indonesia being hardest hit and the United States least affected. Government expenditure is expected to rise by 0,22-0,59%. Calculated GDP losses caused by the pandemic range from 0,7% in Saudi Arabia to 2,5% in Japan. Global mortality is expected to be over 15 million during the first year. (Mckibbin & Fernando 2020)

In the second scenario, the estimated negative shock to consumption demand ranges from 1,86% to 2,66%. Negative shock to labour supply is estimated to be 0,87-2,91%. Government expenditure is expected to rise by 0,54-1,49%. Calculated GDP losses caused by the pandemic range from 1,4% in Saudi Arabia to 5,7% in Japan. Global mortality is expected to be close to 38 million during the first year. (Mckibbin & Fernando 2020)

In the third scenario, the estimated negative shock to consumption demand is between 3,35% in Saudi Arabia and 4,78% in the USA. Negative shock to labour supply is estimated to be 1,3-4,56% depending on region, with Indonesia being hardest hit and the United States the least affected. Government expenditure is expected to rise from

0,98% in the USA to 2,67% in developing countries. Calculated GDP losses caused by the pandemic range from 2,4% in Saudi Arabia to 9,9% in Japan. Global mortality is expected to be over 68 million during the first year. (Mckibbin & Fernando 2020)

The estimated death toll in these scenarios is a lot higher than the current situation is or what is currently anticipated, but the case fatality and infection rates used in the study are possible. Expected increase in government expenditures and the decrease in consumption demand are very low even in the most severe estimate. The case fatality rate in the model also depends heavily on the level of spending in health care, but as there is no cure for the virus, the impact of health care on mortality is limited. For example, in the first scenario overall mortality is lowest in the USA at 0,07% and 236 000 deaths in the first year, as they spend the most on health care. The mortality rate for China is 0,20%, almost triple that of the USA, with 2,8 million expected deaths in the first year. (Mckibbin & Fernando 2020)

#### 5.2.2 Impact on global trade and GDP

The Organisation for Economic Co-operation and Development (OECD) has estimated that the direct impacts of shutdowns caused by the pandemic reduce output by 20-25% and consumers' expenditure by more than 30%. These changes would be much higher than the drops experienced during the financial crisis of 2008-2009, and they only include the initial impacts to the affected sectors. OECD assumes the initially affected sectors include travel, tourism, contact-intensive services, recreational activities, non-essential construction work and manufacturing of transport equipment. It is likely there will be secondary effects to other sectors, especially if the situation becomes prolonged and causes demand to decline. (OECD 2020)

The strict containment policies are estimated to cause a 2% decline to the annual GDP for each month the policies are in place. With a three-month long shutdown, the impact on annual GDP would be 4-6%. As OECD only accounts for the initial and direct impacts to the affected sectors, it is possible that every month with containment policies will be worse than the previous. Secondary effects are more likely as the shutdowns continue, with the impact spreading to other industries causing reduced output, demand and permanent business failures. (OECD 2020)

World Trade Organization (WTO) expects world merchandise trade to fall by 13-32% due to disruptions caused by the pandemic. The decline is expected to exceed the drop in global trade caused by the global financial crisis in 2008-2009. WTO presents two scenarios, an optimistic scenario and a more pessimistic scenario. In the optimistic scenario global merchandise trade declines by 13% in 2020, with recovery starting in the second quarter of 2020 and trade increasing by 21% in 2021. Annual change in global real GDP is -2,5% in 2020 and 7,4% in 2021. Recovery is strong enough to bring the volume of trade close to pre-pandemic levels. The optimistic scenario assumes the pandemic is a one-time event and quickly under control. (World Trade Organization 2020)

The more pessimistic scenario expects world merchandise trade to plummet by 32% in 2020, recovering by 24% in 2021 from a lower starting a point. In the pessimistic scenario the pandemic is prolonged, and uncertainty becomes prevalent, causing a decline in consumption. This leads to a steeper decline and slower recovery. Annual change in global real GDP is -8,8% in 2020 and 5,9% in 2021. The pre-pandemic trade volume is not reached again. (World Trade Organization 2020)

OECD also warns about the risks of protectionism: unified global actions against the pandemic and open markets increase the chances for an optimistic scenario. There is also a risk of supply-chain disruption due to shutdowns, closed borders and protectionism. The calculations of OECD do not include the service sector, which is likely to be the most affected by the coronavirus pandemic. Even though global trade of services is a small fraction of the total service industry, suffering of service industry directly impacts production and transportation of merchandise goods. (World Trade Organization 2020)

### 5.2.3 Impact on employment

In Finland the number of unemployed people has risen by 20 000 due to the pandemic, as of April 16th, 2020. 141 000 have been laid off, but this number does not include those who have been laid off temporarily. By April 16th more than 420 000 labourers were negotiating with their employers about future co-operation. (Ministry of Economic Affairs and Employment of Finland 2020)



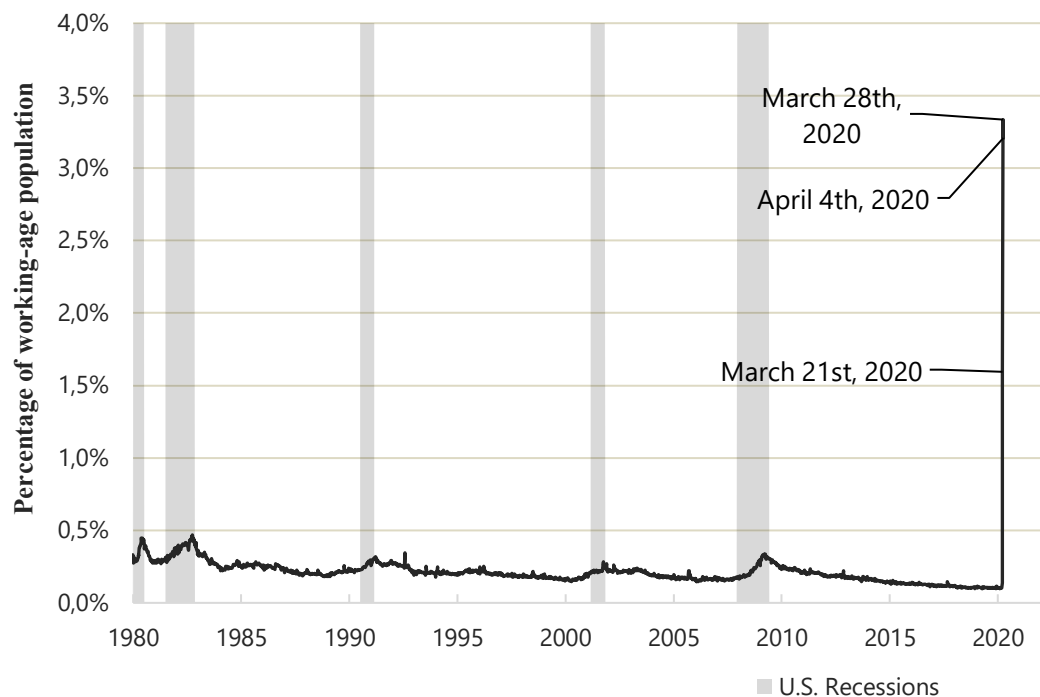
In the United Kingdom the Department for Work and Pensions said that nearly a million successful applications for universal credit benefits had been made in the last two weeks of March. Usual amount of applications is around 100 000. Universal credit is a monthly benefit for working-age people, which has consolidated jobseeker allowance, housing benefit, child tax credit and working tax credit. (BBC 2020)

Before the coronavirus crisis the record number of weekly initial unemployment insurance claims in the United States was 695 000. In 2020, the number jumped from 282 000 in the week ending on March 14th to 3 307 000 for the week ending on March 21st. The next week, ending on March 28th, saw again a new record of 6 867 000 initial unemployment insurance claims. The high numbers continued on the week ending on April 4th, as the number of claims was 6 606 000. The week ending on April 11th had 5 245 000 claims, but the week had only 4 working days. These numbers are illustrated in figure 3. (U.S. Employment and Training Administration 2020)

Unemployment numbers are expected to keep rising significantly, and a stimulus package giving unemployed people 600\$ weekly probably increases the numbers even more. The unemployment benefit is more than twice as much as the federal minimum wage and exceeds the average salary in hospitality and leisure by more than 50%, so becoming unemployed is beneficial for many employees. The same package also makes self-employed, part-time workers and those who are ill eligible for compensation, so a continued surge in initial unemployment claims is expected. (The Economist 2020a)

Some of the estimates about how high the unemployment will rise in the United States predict unprecedented numbers. The unemployment rate in February 2020 was around 3,5%, and the New York Times estimates that the real unemployment rate at the beginning of April is already around 13%. This would mean the unemployment rate has almost quadrupled in two months, with most of the increase happening in three weeks. With a labour force of 164,5 million, that would be a rise from 5,76 million unemployed to 21,39 million, a staggering 15,6 million increase. (The New York Times 2020c)

Some estimates paint an even darker picture. One quickly calculated estimate by the Federal Reserve Bank of St. Louis predicts that unemployment in The United States could reach 32,1% in the second quarter of 2020, a total increase of 47 million persons (Faria-e-Castro 2020). With those numbers the unemployment would be higher than during the Great Recession, when unemployment peaked at 24,9%, and the absolute number of unemployed would be more than three times as much (CNBC 2020a). Goldman Sachs initially predicted that unemployment would reach 9% by the middle of the year but revised the figure to 15% at the end of March. (CNN Business 2020)



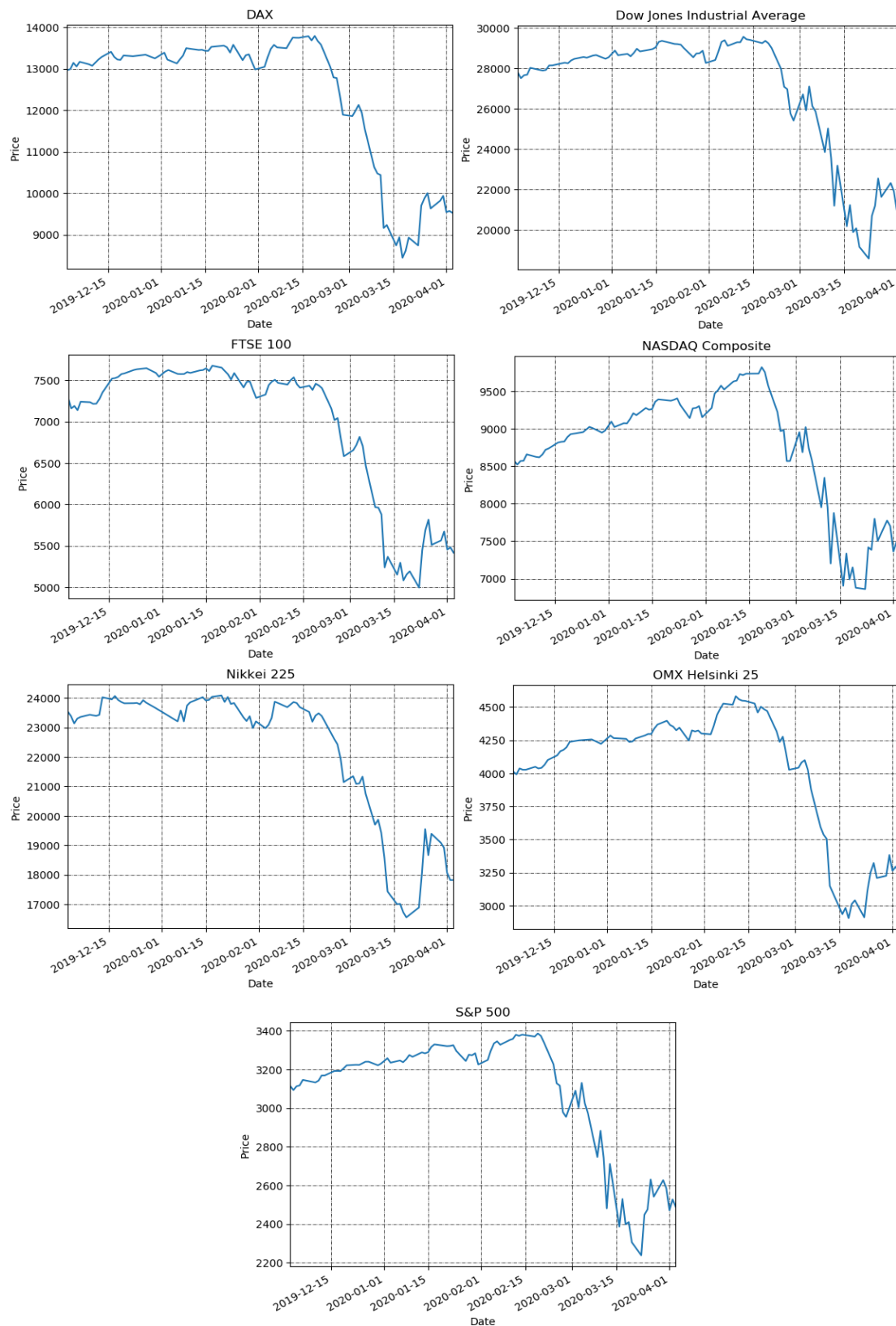
**Figure 4. Weekly U.S. unemployment claims as a percentage of working-age population, seasonally adjusted. Last updated April 16<sup>th</sup>, 2020. (U.S. Employment and Training Administration 2020).**

The International Labour Organization (ILO) calls the pandemic the worst global crisis since the Second World War. On April 7, 2020, lockdown measures impacted 81% of the world's workforce, and ILO estimated that global working hours will decrease by 6,7% in the second quarter of 2020. This is equivalent to 234 million full-time workers, assuming a 40-hour work week. Additionally, 38% of the global workforce is employed in sectors that will be hardest hit by the pandemic. (International Labour Organization 2020)

#### 5.2.4 Impact on the financial markets

As the COVID-19 has progressed into a pandemic, stock markets around the world have become increasingly volatile with very high average daily losses and returns. Between mid-February and the last week of March, most stock indices lost about a third of their value. Figure 4 illustrates the price drop and associated volatility. The US stock market had the fastest decline into bear territory (a decrease of 20%) ever. The shock was faster than during the Great Depression or the global financial crisis. Credit markets seized up and credit spreads have spiked to the levels they were in 2008. (Roubini 2020)

Since then most indices have again started to increase in value, as governments and authorities have announced stimulus packages. Growth has not been impacted by continuously direr forecasts and released economic figures. A recent article by Gormsen and Koijen forecasts future dividends and predicts that annual growth in 2020 will be -27% in the USA and -37% in the EU. The lower bound estimate for the change in expected dividends is -45% in the US and -58% in the EU for a 2-year horizon. (Gormsen & Koijen 2020, Yahoo Finance 2020)



**Figure 5. Price development of selected stock indices during the COVID-19 pandemic, as of April 6, 2020 (Yahoo Finance 2020).**

### 5.2.5 Impact on the energy sector

The pandemic has also had a significant impact on the energy sector, especially oil and gas. Collapsed demand and a price war between Saudi Arabia and Russia caused the price to drop to a third of what it was at the beginning of 2020 (situation at the beginning of April 2020). WTI Crude, for example, fell from 63 dollars per barrel to around 20 dollars per barrel. Forecasted decline in the global demand for oil during April is 20%, having already fallen by six million barrels per day in the first quarter. Overproduction combined with a steep decline in demand could possibly fill the entire global storage capacity by early May, causing prices to drop even more. (Foreign Affairs 2020)

At the moment of writing, there is some hope for a deal between Saudi Arabia and Russia. That would not remove the fact that global demand is at a low level and likely will remain low for an extended period of time. Prolonged low oil price would have major consequences for oil producing countries. Russia has balanced its budget on the assumption that a barrel of oil would cost 42\$, and for Saudi Arabia the required price to balance budget is 80\$. Reduced demand and price would be hurtful especially for the shale oil industry in the United States, where there are 2,5 million jobs related to the industry, as shale oil has high production costs. (Foreign Affairs 2020)

### 5.2.6 Government stimulus during the crisis

As the pandemic has forced governments to restrict movement of people and business activity, many governments throughout the world have announced stimulus programs to counter the negative economic shock. Some of these announced packages have been record high. Central banks in the United States of America (Federal Reserve) and in the Euro-area (European Central Bank) have announced that they are ready to provide unlimited quantitative easing. (Bloomberg 2020, The Federal Reserve 2020)

The details of many of the stimulus packages announced by countries are vague, and it is hard to do a comparison between countries. The situation also evolves continuously, with more stimulus announced and details and amounts changing. For these reasons it is very hard to provide a quick overview of the policies adopted by

different countries, Stimulus packages for selected countries are displayed in table 2. For a more thorough list and further explanations, I suggest visiting the policy tracker of the International Monetary Fund.

**Table 2. Size of stimulus in different countries as of April 9, 2020. Sources: IMF (International Monetary Fund 2020) and CNBC (CNBC 2020).**

Country	Direct spending	Loan guarantees, asset purchases etc.	Combined % of GDP
USA	\$2,4 trillion	Up to \$6 trillion	39,7%
UK	£39,7 billion	£330 billion	13%
Japan	¥108,2 trillion	Not specified	20%
Italy	€25 billion	€400 billion	26,4%
Germany	€204 billion	€820 billion	32,2%
Sweden	SEK 380-668 billion	SEK 800 billion	23,6-29,3%
Finland	€18,7-21 billion	€13,2 billion	14,2-15,2%
EU	€577 billion	€870 billion	10,7%

### 5.2.7 Developing countries

Even though the pandemic has not yet spread in its full force to developing countries, its economic impacts are already materialising. Many developing countries rely heavily on tourism or exporting commodities, including oil, and these industries have already been hit heavily. Since the beginning of the year, the overall price decline of commodities has been 37% causing a decrease in export revenues. (United Nations Conference on Trade and Development 2020)

At the same time their currencies have weakened 5-25% against the dollar. This has led to an increase in the price of imports, and dollar-denominated debts have become more expensive to pay. Portfolio outflows from the main emerging economies were 59 billion US dollars during a one-month period between February and March. Risk premiums have increased as a result, and borrowing is becoming increasingly expensive. (United Nations Conference on Trade and Development 2020)

Since 2007, total public and private debt in emerging economies has risen from 70% of annual economic output to 165%. As currencies fall and costs of debt rises, many countries have a risk to become insolvent and default. High debt levels also prevent the governments of developing countries from providing sufficient economic support. If heavily indebted countries would provide generous aid to affected individuals and businesses, how would the debtors react? (The New York Times 2020a)

Developing countries are also ill-prepared to deal with a full-blown outbreak. Their health-care systems are underequipped and lack capacity, especially for intensive care. Social distancing is hard in crowded urban centres, and basic hygiene is hard to maintain without running water. Governments also lack the financial possibility to build strong safety nets for the unemployed. (The Economist 2020b)

The pandemic also has a large effect on employment in developing countries. Globally, around 2 billion people work informally, most of them in developing countries. Informal workers lack social protection and have no income if they are sick or otherwise absent. They have worse access to health care than regular workers, and

work often in low-paying jobs that require human interaction and therefore are affected by lockdowns. (International Labour Organization 2020)

The United Nations University (UNU-WIDER) has estimated that if global per capita incomes decrease by 5%, the number of people living with under 1,9\$ per day would increase by more than 80 million. The total number of people living with under 5,5\$ per day would increase by more than 330 million, bringing global poverty levels back to the where they were a decade ago. If per capita incomes would decrease by 20%, the amount of people living with under 1,9\$ per day would increase by 420 million. The total increase in the number of people living with less than 5,5\$ per day would be more than 1,5 billion, and the global poverty levels would be equal to those of 1990. (Sumner et al. 2020)

There are also positive aspects that could limit the impacts of the virus. Population in poor countries tends to be young, and thus in a better position to handle the virus. Rural areas are also likely to be not as badly affected, due to limited social contacts. Hot and humid climate may also slow down the spread of the disease. (The Economist 2020b)

### **5.3 Resilience and the impact of different policies**

As discussed in the chapter 4 of this thesis, the resilience of a society and its economy during a pandemic depends on the basic reproduction rate of the virus,  $R_0$ , and the level of mobility,  $p$ . The global invasion rate, which is the point when the pandemic starts to spread, is a function of these two. As long as the global invasive threshold,  $R_*$ , is not reached the pandemic is under control and starts to contract. Resilience of a system is high and the overall mortality low when restrictions are strict enough to bring the pandemic to a halt. If the measures taken to restrict mobility are not sufficient to go below the global invasion rate, the pandemic becomes prolonged and resilience suffers. (Massaro et al. 2018)

Considering only resilience, there seems to be two optimal decisions when facing a pandemic. First of them is to implement no restrictions at all, leading to a brief pandemic. Due to the short time resilience remains high, but mortality is also high. The better option, if feasible, is to limit mobility to the point the disease stops



spreading. The first option could cause a very high death toll and is not preferable when other factors than resilience are considered. (Massaro et al. 2018)

A recent publication by the Imperial College of London considers the same question of limiting movement from a social and health perspective and gives some support to the idea that very severe restrictions on mobility should be implemented as fast as possible, if feasible. The paper considers two different ways countries can try to stop the spread of coronavirus, these being mitigation and suppression. Mitigation refers to the efforts to slow down the spread of the virus, instead of stopping it. Suppression aims to reverse the epidemic growth and stop the virus from spreading. (Ferguson et al. 2020)

The paper includes two countries, UK and the USA. It examines the impacts of different mobility restrictions on total mortality and hospital usage. With strategies to only mitigate the pandemic, critical care bed capacity is reached in calculations with all different combinations of movement restrictions. The best mitigation effect is achieved with isolating symptomatic individuals, home quarantining when a case is identified in a household and applying social distancing for those over 70 years of age. Even in this scenario the required amount of critical care beds during the peak is more than 8 times the capacity. (Ferguson et al. 2020)

In order to suppress the pandemic more restrictions are needed and for a longer time, in this model the estimated time is 5 months. Combining case isolation, social distancing of the entire population, household quarantines and school closures, the critical care bed capacity is not reached during an initial outbreak. Suppressing the pandemic has also its downsides. As the total amount of people who go through the disease is lower, no herd immunity in the society is built. This means that there is a risk for a second wave if the restrictions are lifted before the disease has died out. Without a vaccine or herd immunity, there is a risk that a country needs to be shut down repeatedly, causing enormous economic damage. Waiting for a vaccine can take potentially 18 months, which is a very long time to maintain reduced mobility and social distance. (Ferguson et al. 2020)

With heavy restrictions on mobility, it is possible to suppress the pandemic enough to the point when it becomes feasible to start trying to eradicate the virus. With intensive testing and tracking of cases, combined with quarantining exposed individuals, it could be possible to stop the virus. Technology could be useful in helping to track movements of people with mobile applications. This would make it easier to find those who have been exposed to the disease. (Ferguson et al. 2020)

Suppression and tracking of cases are very expensive and requires expertise and a level of governance not found in all countries. It is also possible only in the early stages of the epidemic, when the number of infected is still low. Countries that can try to limit and stop the spread of the virus should do so as soon as possible. Complete suppression of the virus quickly leads to fewest deaths and infections, and it is also the best action resilience-wise. (Ferguson et al. 2020)

An article published by the Bank of Finland considers the economic consequences of both mitigation and suppression for Finland. There are two possible ways to suppress the spread: an extensive lockdown for the whole population or lighter restrictions combined with wide-spread testing and tracking of cases. Several Asian countries have seemed to be successful in suppression, China with an extensive lockdown and South-Korea, Singapore, Taiwan and Hong-Kong with testing and tracking. The countries that have chosen to suppress the virus from the beginning all experienced the outbreak of SARS. (Bank of Finland 2020)

Mitigation is also defined in this article as the actions taken to slow down the spread of the virus, “flattening the curve”, in order to make sure the capacity of health care is not reached. If mitigation is chosen as a strategy, the actions need to be implemented for a long time, possibly 6 months. The length of restrictions to suppress the pandemic is 8 weeks in the calculations. (Bank of Finland 2020)

With actions to suppress the virus, the economic impact will be smaller than with mitigation. The GDP drop in the second quarter of 2020 would be 11% from the first quarter but starts to recover in the third quarter. The growth rate of GDP will be -5% in 2020 and 7% in 2021. In the suppression scenario, there are no major long-term effects for the economy. (Bank of Finland 2020)

The lighter restrictions taken to mitigate the spread of the virus have more severe consequences for the economy. As the restrictions exist for a longer period in the second quarter, the GDP would drop by 15%. The growth rate of GDP will be -13% in 2020 and 4% in 2021. As the time of decreased economic activity increases, businesses start to fail, and unemployment continues to rise. Unemployment will be higher for several years, and the ratio of government debt to GDP will 20% higher in 2022 than it would be with suppression. Due to business failures the pre-pandemic output level is not reached, and the permanent loss of production is 10%. (Bank of Finland 2020)

The article notes some of the possible risks of suppression strategy, which are largely the same as those mentioned in the paper written by the Imperial College of London. The restrictions required to suppress the virus may be very expensive or even impossible. There are also no guarantees that the suppressive restrictions would work and bring the case numbers to a low enough level. A country without herd immunity is also vulnerable to new waves of the pandemic if other countries are unable to control the virus, and movement is allowed between countries. (Bank of Finland 2020)

It seems that the best action from multiple different points of view is quick suppression, with strict restrictions from the beginning. The fewer cases there are, the easier it is to suppress the virus. The shorter the period of limited economic activity, the better it is for the economy in the long run. If it is possible, efficient suppression that stops the spread of the virus is also the best for the resilience. Restrictions are likely necessary to stop a second wave until there is a vaccine for the virus, especially if other countries do not choose suppression as their strategy.

#### **5.4 What will the future bring?**

A lot of the future of the current pandemic is unclear. Nobody knows whether this a one-time event, such as SARS, or a new disease that mutates and returns every year like influenza. There is also the possibility that the world will experience a few waves of this coronavirus before it disappears. (Kissler et al. 2020)

The severity of the overall economic consequences depends largely on the length of the pandemic: how fast the pandemic is contained and whether it will be a one-time event. As the pandemic progresses, the hopes of a quick recovery diminish every day. The pandemic could potentially become a cyclical disease, or it could move from one part of the world to another, depending on where the policies to stop the spread are strongest at the time.

If the pandemic becomes prolonged and leads to business failures and massive unemployment, there is a real chance for a severe global depression. Current levels of government stimulus are likely unsustainable for an extended period, and if the level of fiscal support slows down there will be a new wave of bankruptcies leading to a further increase in unemployment and a reduction in overall output. Long-term impacts to both supply and demand would increase the likelihood of a slow and difficult recovery.

There may be long-lasting impacts to the global psychology of consumers and businesses. Individuals may avoid travelling and large public gatherings for a long time, and consuming habits learnt during shutdowns possibly persist for a duration that is longer than the span of the pandemic. Investing and risk in general may be avoided: the world might be more risk-averse for some time. Risk in general may be re-evaluated. Will the risk of black swan phenomena (unpredictable events) become something that is prepared for? What happens to equity risk premiums if governments do not allow certain businesses to fail?

Not every country and industry will be impacted similarly. As some regions are more resilient than others, due to industrial diversity or some demographical feature, the direct impacts will vary between regions. Perhaps regions that have a more diverse and dynamic industrial structure and workforce are better suited to deal with the pandemic, as they are able to work from home and increase production in less hit industries. Regions specialising in medical equipment for example may benefit from the crisis. There will of course be indirect effects that affect globally.

Governments should provide instant and sufficient support for companies to survive the pandemic, thus preserving jobs and the future output potential. This will be done

with new debt in most countries, and the cost depends largely on the length of the pandemic. Quick suppression of the pandemic and minimising bankruptcies should be priorities for countries that have the possibilities to do so. Actions that seem exaggerated today would minimise the length of the pandemic, and the long-term economic and social consequences.

The increase in debt for both companies and governments can also cause troubles in the future. If the stock prices remain at a lower level, and companies must take debt to survive the pandemic, debt to equity ratios will be altered. Governments will also end up with higher debt to GDP ratios, as GDP declines and debt levels accelerate quickly. Developing countries with dollar or euro nominated debts will be especially vulnerable, potentially becoming insolvent if their interest rates stay at a higher level and the prices of commodities remain low.

Globalisation can potentially take a step back. Disruptions in supply-chains and problems in trying to acquire medical gear when production has been shifted to China have become real issues (EUobserver 2020). To hedge against supply-chain disruptions, it is possible that the share of domestic production will increase around the world. Countries have also limited movement by closing their borders, and it is possible that all the restrictions will not be lifted when the pandemic situation eases. (Foreign Policy 2020b)

One thing is certain: there will be a huge surge in economic literature related to pandemics and unexpected external shocks. As different countries are reacting differently and implementing different policies, both from economic and social perspectives, there will be a lot of data to analyse after the pandemic. Which strategies work the best will be seen only as time goes on. Will it be mitigation or suppression that minimises the impacts of the pandemic? What kind of economic policies prove to be useful to counter the current situation? For example, USA has chosen to support those who are unemployed, whereas many European countries try to support businesses to stop unemployment. (Foreign Policy 2020a). Which strategy will be better in the long run?

## 5.5 Recent and relevant literature

There already exists a large number of published theoretical research into the economic effects of pandemics, inspired by the current COVID-19 pandemic. As their results are often contradictory and methods complex, including all of them in this paper would be hard and the thesis would likely become arduous to follow. Therefore, I will list some of them here for those who are interested.

Baldwin and Weber (2020) have published an e-book, which collects thoughts from several economists about the economic consequences of the pandemic. (Baldwin & Weder di Mauro 2020)

Fornaro and Wolf (2020) considered the potential macroeconomic effects of the COVID-19 pandemic, and especially the scenario of a persistent and severe supply disruption caused by the pandemic. (Fornaro & Wolf 2020)

Faria e Castro (2020) considered the pandemic as a shock to the utility of services requiring human contact, which spreads to other sectors and leads to a deep recession. The paper studied the effects of different fiscal policy instruments and analysed the effectiveness of the \$2 trillion stimulus package in the USA. (Faria e Castro 2020)

Alvarez et al. (2020) studied the optimal lockdown policy balancing mortality and economic losses, including the value of a statistical life in calculations. Their results supported a severe lockdown starting two weeks after the outbreak, combined with large-scale testing. (Alvarez et al. 2020)

Berger et al. (2020) used an infectious disease epidemiology model (SEIR) to analyse the impact of wide-spread testing. They showed that with large-scale random testing of asymptomatic individuals and looser quarantining, the death toll will be similar to a scenario with large-scale quarantines and limited testing. Large-scale testing also reduces peak symptomatic infections, reducing stress for hospitals, and dampens the economic impact of the pandemic. (Berger et al. 2020)

Eichenbaum et al. (2020) found that people's choice to reduce consumption and working during an epidemic lowers the total death toll but cause worse economic consequences. Simple containment policies that limit mobility help to save lives, but they lead to a worse recession. The authors advocated a model of adaptive "smart containment", which takes people's health and overall immunity into account. (Eichenbaum et al. 2020)

Jorda et al. (2020) studied the rates of return on assets from 15 historical pandemics, starting from the Black Death. They found that pandemics have long-term economic consequences: real rates of returns are depressed for 40 years after a pandemic. They also claimed that real wages are higher for a period of time following pandemics. I find the applicability of these results limited to the current pandemic, as the global economy has changed completely since the last real pandemic in 1918. (Jorda et al. 2020)

Guerrieri et al. (2020) demonstrated that the supply shocks caused by the pandemic may cause changes in the aggregate demand that are larger than the shocks themselves. Firm exits and following job destructions can strengthen the negative effects. They found that the optimal stimulus policy is to prevent firms from exiting the markets, thus maintaining the employer-employee connections and leading to faster recovery. (Guerrieri et al. 2020)

Baker et al. (2020) studied how household spending responds to a pandemic. They found that in the early stages of a pandemic the spending increases sharply, mainly in retail and food items. As the pandemic spreads, the spending falls sharply. The decrease is larger when there is a lockdown in place, which is expected. (Baker et al. 2020)

## 6 DISCUSSION

“Principiis obsta; sero medicina paratur cum mala per longas convaluere moras.” (Ovid, around 17 AD)

“Stop it at the start; it is late for medicine to be prepared when disease has grown strong through long delays.”

(Bloom & Canning 2006)

The following quote from the Roman poet Ovidius, who lived more than two thousand years ago, is still relevant. No matter from which perspective epidemics and pandemics are viewed, prevention and isolation of new diseases is extremely important. It is the best for individuals, countries and the whole world. Preventing the emergence and spread of new pandemics saves the world from terrible humanitarian and economic consequences.

When a pandemic has already started to spread, stopping it is very difficult. Slowing down the pandemic, however, is possible with restrictions that reduce human mobility and limit social contacts, giving the disease less opportunities to infect people. These restrictions have a price on the economic functionality, and when prolonged they reduce the resilience of a society (Massaro et al. 2018). At the same time, they reduce the risks from the pandemic, leading to fewer deaths and infections. Controlling the spread of a pandemic after an outbreak becomes also a question of ethics and policy. What is the value of a human life, how much letting the pandemic run its course freely would cost? Should societies prioritise the economy or minimise risk to its citizens?

Even during the Black Death there were arguments between different authorities regarding the choice between restricting movement and protecting the people or allowing people to move which would help businesses. The authorities in cities like Milan and Florence backed the public health commission, which was established to counter the plague, and implemented strict restrictive measures. The church and business circles opposed the restrictions, as they would suffer from reduced economic activity. City authorities chose to protect the long-term economic health by protecting the populace, instead of yielding to the demands of continued business for short-term



relief. Much of this arguing 700 years ago sounds oddly familiar today, when there is lots of arguing about how much the functioning of societies and economies should be restricted. (Bell & Lewis 2004)

During the current coronavirus pandemic many countries have implemented various methods to limit human contacts. These include restrictions on the movement of people, quarantines and banning social gatherings. Most of the countries have implemented only limited or partial restrictions, allowing a certain degree of mobility. Previous researches have supported the idea that a partial shutdown does not prevent the spread of an epidemic, only a full and strict quarantine can. Or in simpler words: “having places shut down and places not shut down is like having a peeing section in the pool” (deafmute88 2020). Quarantines that are very strict, however, are extremely difficult to implement in practice. In a modern world where transport networks are global and extensive, maintaining very severe travel restrictions is almost impossible (Massaro et al. 2018).

How different stimulus packages and fiscal support affect the recovery of countries after the current crisis is also interesting. Will countries that have announced very large stimulus packages recover faster from the shock? And if they do recover faster, will the long-term growth rate be lower due to higher amounts of debt, as has been the case for Japan in the past decades?

Some countries have chosen to support companies to stay afloat by paying their employees' salaries, lowering unemployment figures and the amount of business failures. Is this good for the resilience and long-term growth? On one hand the initial recovery may be faster due to the already existing employee-employer pairing, and because now time is spent to start new businesses. On the other hand, generous financial support to all companies allows even the bad companies to stay in business, leaving no room for the Schumpeterian “creative destruction”. Does financial support of failing companies lead to a slower growth path, one filled with a large amount of heavily indebted and government subsidised unprofitable companies?

As the coronavirus pandemic has progressed and its economic implications have become clearer, it has become obvious that old models and estimates of the economic

impact of a potential pandemic are outdated. They have underestimated how far-reaching and wide the consequences are. How willing governments are to restrict movement is probably also something researchers are surprised about. The effect on financial markets has also been substantial.

There has been a huge spike in unemployment, partly caused by government restrictions. Even though governments have taken a strong role during the crisis by supporting businesses and individuals financially, a lot of businesses are expected to fail. Unemployment reduces demand, leading to further business failures. If the situation continues for a longer period, the economic resilience is likely to suffer leading to harder and longer recovery.

After the crisis, and hopefully during it, there is a need for increased global co-operation in epidemic prevention and preparedness. The current coronavirus pandemic has demonstrated that it is in the interest of the whole world to stop new diseases from emerging and spreading. It has also become evident how unprepared most of the countries are to deal with a pandemic, only those countries that experienced the SARS outbreak seem to have had proper plans and precautions in place.

As quarantining entire regions and shutting down economic activity is very expensive, it is often the last action that the government is willing to take, even though it would be the best alternative in the long run. The existence of a global “insurance fund” designed to give financial support to regions where outbreaks occur could potentially stop new epidemics from spreading into pandemics. If all countries would be a part of this insurance fund, shutting down infected regions completely until the disease is eliminated would be a more attractive option as the enormous costs would not have to be paid by the impacted region and its government.

There are many possible actions to prevent new diseases and their spread to epidemics. As many diseases that have the potential to become pandemics are zoonotic (originating from animals), limiting the contact of humans and animals is one way to prevent the emergence of new diseases. One efficient and important step in order to limit the contact of animals and humans is to stop wildlife markets, where live animals are sold for consumers to be used as a food. (The Guardian 2020)

The health of animals also contributes to the health of humans. Animal health systems should be improved to allow for better detection of diseases and preventing the diseases from spreading into an epidemic. Monitoring the health of both wild and domesticated animal populations would make it easier to diagnose new diseases before they are a threat to humans. (Food and Agriculture Organization of the United Nations 2020) Preserving diversity of ecosystems and wildlife habitats also supports animal health. Two thirds of new diseases originate from wildlife, and damaged ecosystems lead to animal populations that are sicker. Deforestation and agriculture also force wild animals into contact with humans, increasing the chance for a new zoonotic disease to be introduced into humans. (The Guardian 2020)

There is an increased need for extensive research into the economic impacts of economics and pandemics. The current pandemic has demonstrated that most countries have been unprepared for such an event, and its economic impacts have not been understood beforehand. After the pandemic subsides and new data becomes available, there will be an enormous amount of opportunities for research. The question of optimal policy when facing a pandemic will likely be an important topic in future research.

The concepts of resilience to pandemics should be developed, and a definition is needed. There is also a need to develop methods to determine and measure both resilience and vulnerability to pandemics. Which variables should be included? Demographics, such as age structure and population density likely influence both vulnerability and resilience. What is the role of industrial structure? Which industries make a country or a region more vulnerable, and does diverse industrial structure improve resilience and recovery?

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